

Reductions in Impingement Mortality Resulting from Enhancements to Ristroph Traveling Screens at an Estuarine Cooling Water Intake Structure

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Protect Aquatic Organisms

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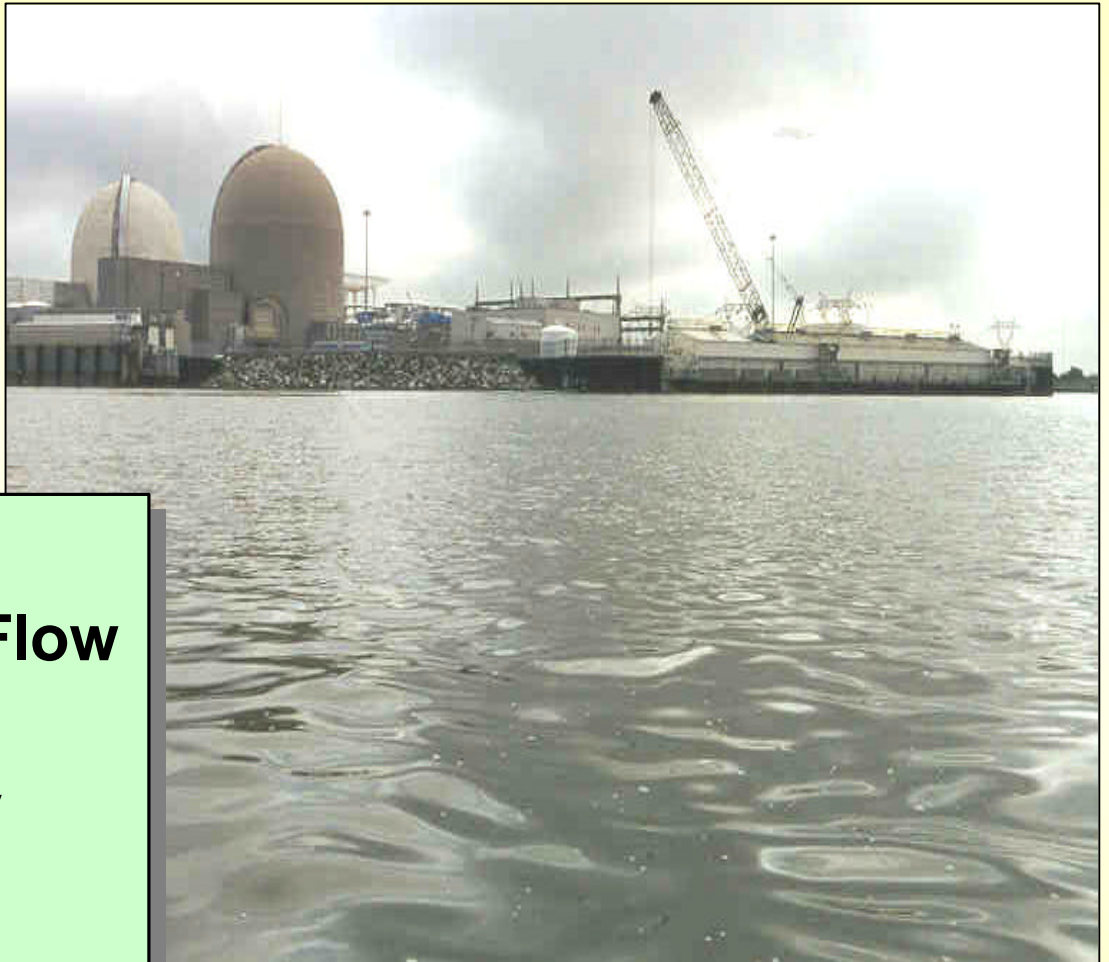
Salem Generating Station

- **Delaware Estuary Steam Electric Plant**
- **Approx. 30 miles SW of Philadelphia**
- **Each unit rated at 1,162 Mwe.**
- **Commercial Operation**
 - Unit 1: 1977
 - Unit 2: 1981



Cooling Water Intake Structure (CWIS)

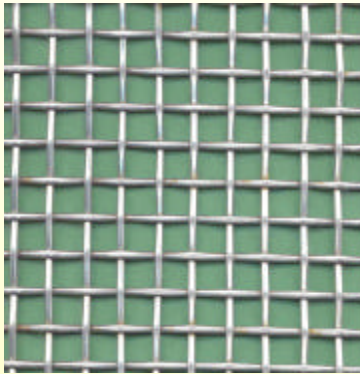
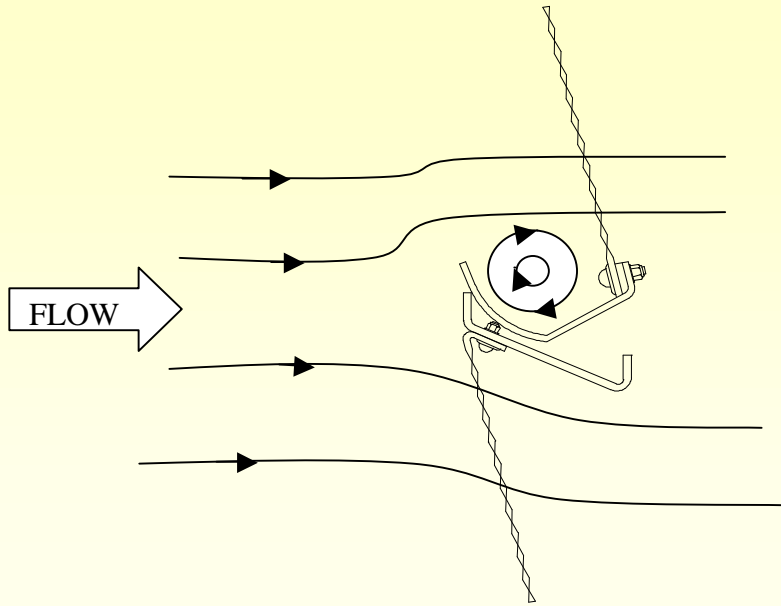
- **12 Intake Bays**
- **Monthly Average Flow of 3,024 MGD**
- **Approach Velocity**
 - 1.0 ft/s at low tide
 - 0.87 ft/s at high tide



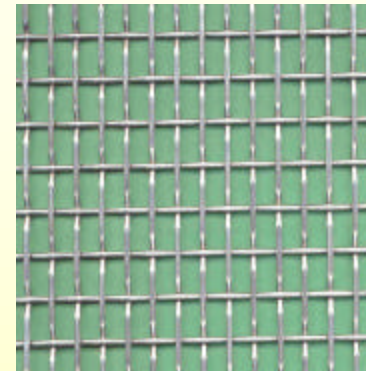
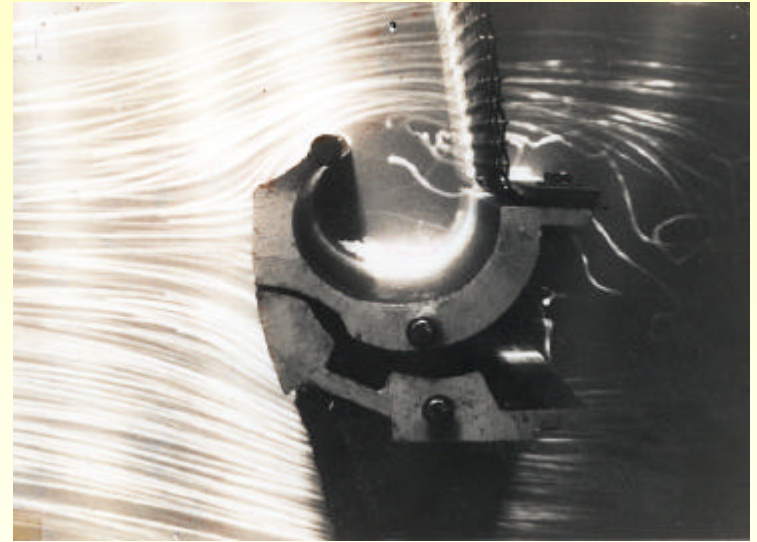
CWIS Traveling Screens



- **12 screens (one per intake bay)**
- **Continuously rotating to remove detritus and marine life**
- **Modified in 1996 to improve efficacy:**
 - Enhanced bucket profile
 - Lighter construction
 - Finer Smooth-Tex TM Mesh (0.25" x 0.5" vs. 0.375" x 0.375" with old screens)
 - Modified spray wash configuration



Original Screens
Bucket Profile & Screen Mesh



Modified Screens
Bucket Profile & Screen Mesh

Salem CWIS Fish Return System

Top Right: Fish spray and flap seals

Below: Fish and debris return troughs

Bottom Right: Fish return trough terminus



Salem CWIS Fish Collection & Holding Facilities



**Impingement Abundance
Sampling in North Fish
Counting Pool**



**Temporary Latent
Impingement Mortality
(LIM) Holding Tank**

1995 Impingement Mortality Direct Comparison Study - Methods

- Unit 2 modified with improved Ristroph screens, Unit 1 retained original screens
- Discharge split to north (U1) and south (U2) pools in 4 to 6 minute samples for comparison
- LIM Samples collected on 19 dates between June 20 and August 24, 1995
- Sampled entire tidal cycle
- Weakfish, bay anchovy and spot targeted for study
- Fish held in six 100 gallon tanks
- Survival fraction observed after 12, 24, and 48 hours

Summary of Results from the 1995 Direct Comparison Study - Weakfish

Original Screens versus Modified Screens

	Original Screens		Modified Screens	
MONTH	Number of fish examined	Impingement Mortality Rate	Number of fish examined	Impingement Mortality Rate
June	111	33%	366	17%
July	367	31%	473	18%
August	553	51%	623	25%
TOTAL	1031	38%	1462	20%

1997–2000 Impingement Mortality Study - Methods

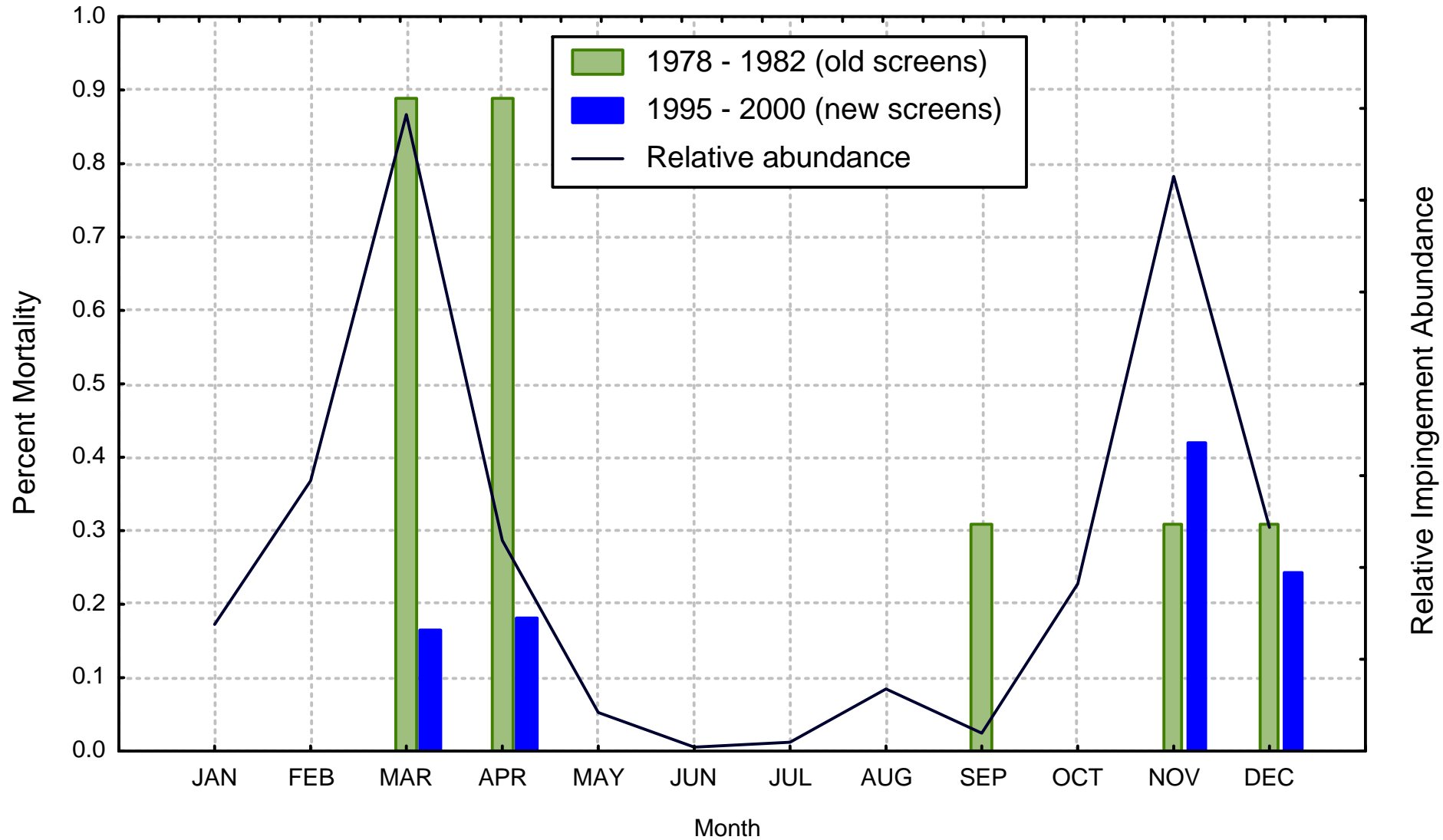
- Modified Ristroph screen improvements completed for both units
- Discharge combined and directed in the direction of the tide
- Sampled entire tidal cycle
- Study targeted weakfish, bay anchovy, spot, alewife, blueback herring, American shad, striped bass, white perch and Atlantic croaker
- Fish held in six 100 gallon tanks
- Survival fraction observed after 12, 24, and 48 hours

Mortality Rate Ranking (Lowest to Highest) for RIS Species Based on 1997 through 2000 Data

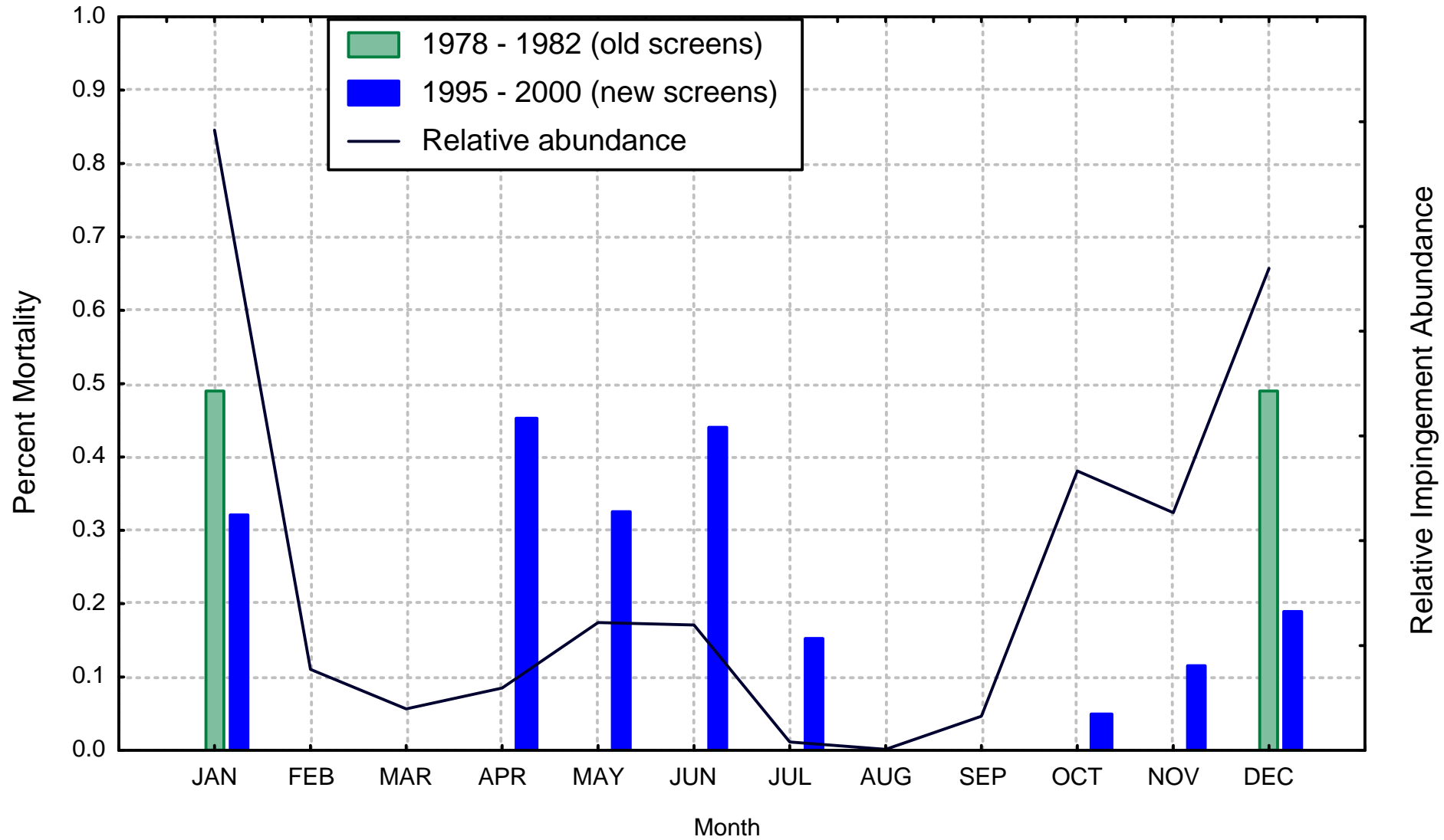
RANK	SPECIES	ANNUAL MORTALITY * (%)	MINIMUM (%)	MAXIMUM (%)	TOTAL NUMBER SAMPLED
1	Striped Bass	4.66	2.10	6.87	1,505
2	White Perch	6.29	0.95	33.63	25,757
3	Spot	6.67	--	--	132
4	Atlantic Croaker	22.64	3.86	44.86	35,186
5	American Shad	23.95	--	--	40
6	Blueback Herring	27.39	14.11	43.38	4,150
7	Alewife	39.15	17.41	43.01	551
8	Weakfish	47.77	10.28	65.25	26,400
9	Bay Anchovy	58.02	27.48	83.97	10,235

* Calculated from abundance-weighted monthly mortality estimates.

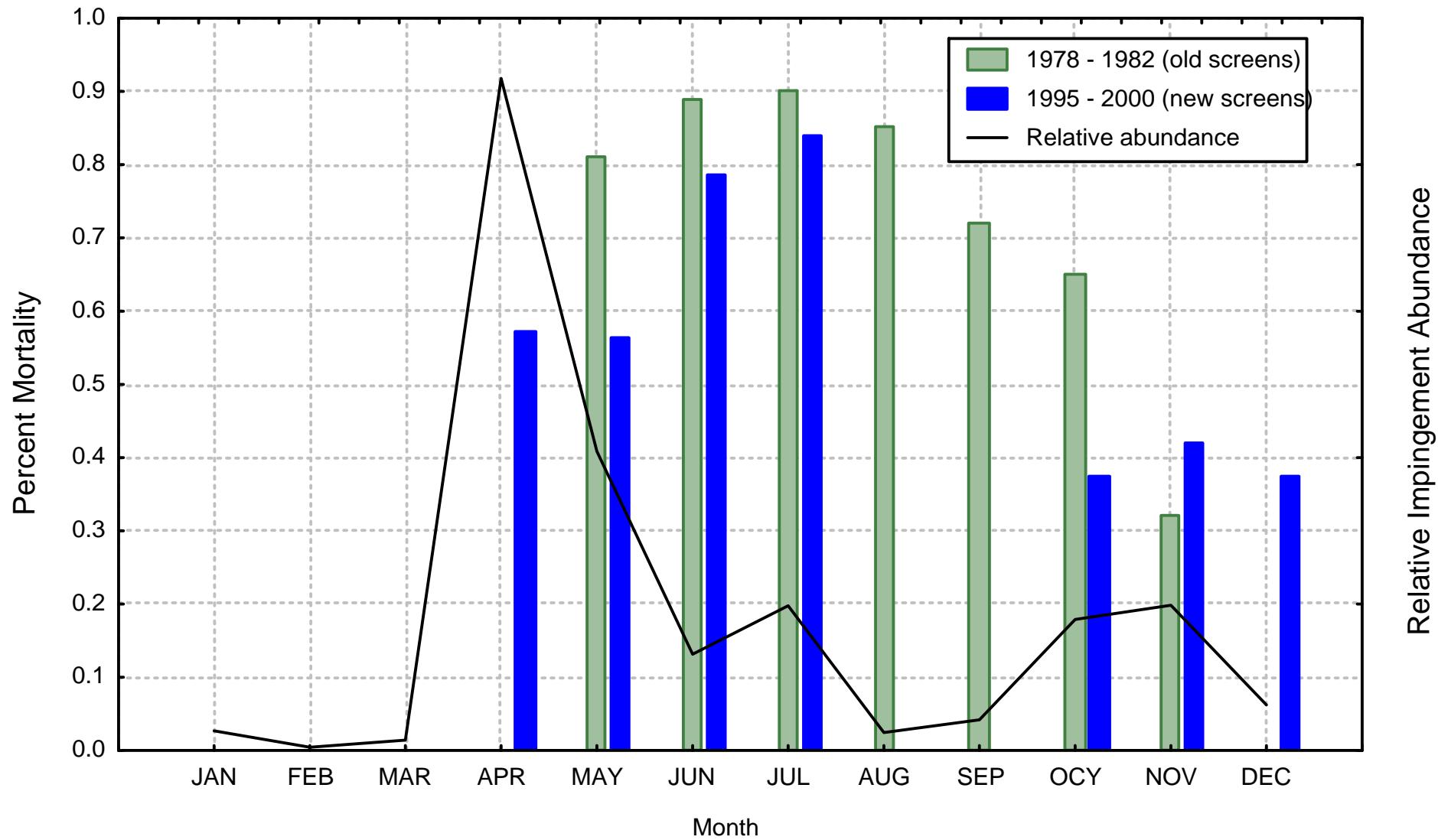
BLUEBACK HERRING AND ALEWIFE



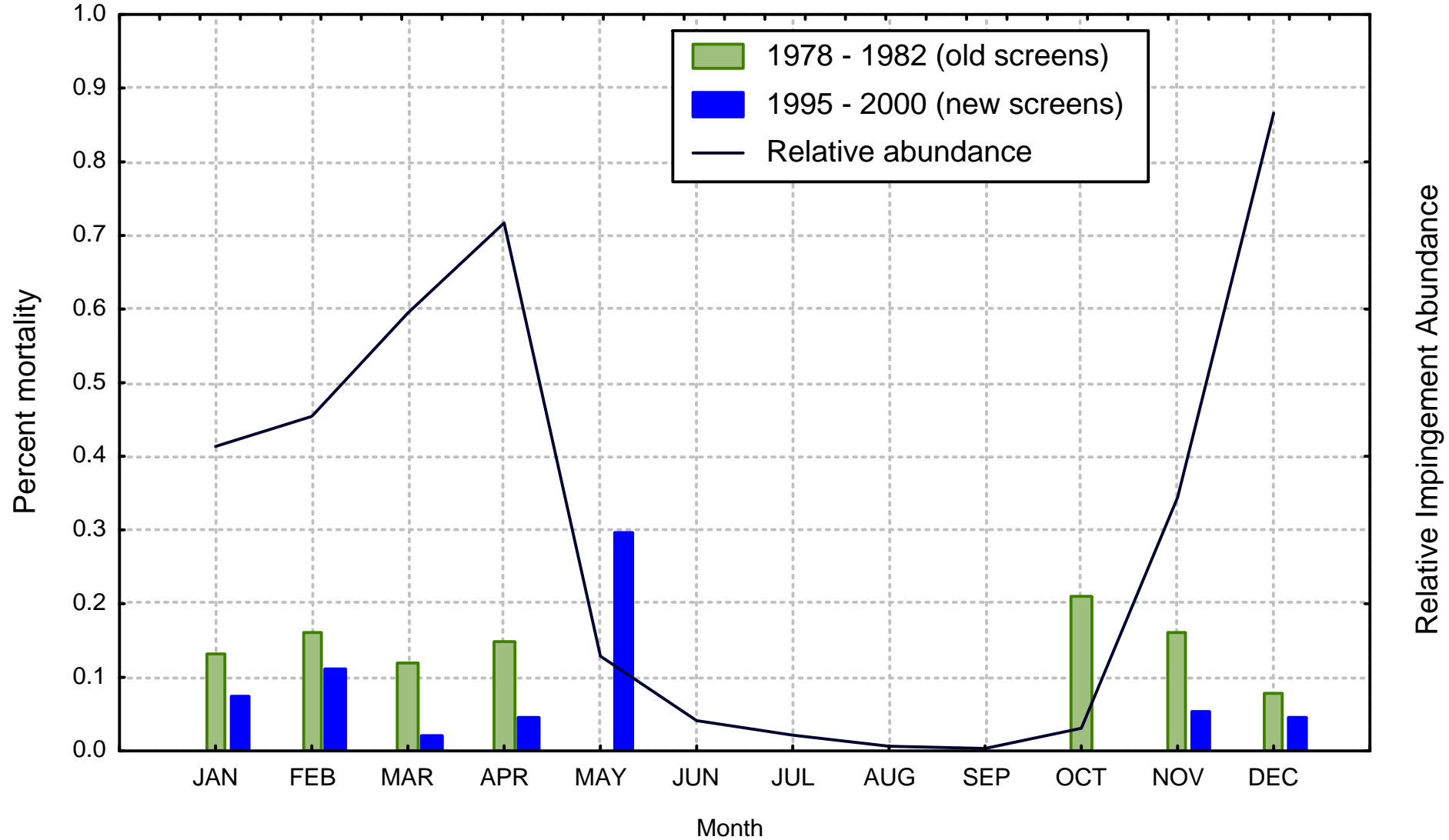
ATLANTIC CROAKER



BAY ANCHOVY



WHITE PERCH



Fish Collection Pool and “End-of-Pipe” Evaluation Methods

- Fish collection pool and “End-of-Pipe” models constructed off-site
- Tests conducted with alewife and weakfish
- Testing performed in both models as well as in the Salem fish collection pools
- Marked control fish included in each replicate
- Survival fraction enumerated after 12, 24 and 48 hours

“End-of-Pipe” Model 6-foot drop configuration



Estimates of survival (standard error) from pooled replicates by treatment with alewife for the end-of-pipe experiment

Treatment	Immediate	48 Hours
Existing Configuration	0.9965 (0.0035)	0.9964 (0.0059)
1.3-ft Freefall	1.0 (N/A)	1.0140 (0.0098)
6-ft Freefall	1.0 (N/A)	1.0034 (0.0034)

Note: Values > 1 indicate higher control mortality

Fish Collection Pool Model



Estimates of survival (standard error) from pooled replicates by treatment for the fish collection pool experiment (Model)

Treatment	Immediate	48 Hours
3 cfs / 25 cm of cushion water	1.0 (N/A)	1.16434 (0.0058)
3 cfs / 50 cm of cushion water	1.0 (N/A)	1.0315 (0.0379)

Note: Values > 1 indicate higher control mortality

Estimates of survival (standard error) from pooled replicates by treatment for the fish collection pool experiment (Station)

Treatment	Immediate	48 Hours
3 cfs / 25 cm of cushion water	1.0034 (0.0058)	1.0034 (0.0058)
3 cfs / 50 cm of cushion water	1.0067 (0.0047)	1.0067 (0.0047)
13 cfs / 25 cm of cushion water	0.9966 (0.0034)	0.9966 (0.0034)

Note: Values higher > 1 indicate higher control mortality

Summary

- Properly designed traveling water screen/fish return systems can effectively reduce impingement mortality rates
- Impingement mortality is variable & can be affected by fish distribution, condition factor, temperature and salinity
- Properly designed fish collection, counting and return systems do not contribute to reported impingement mortality rates